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History Sheet

Rev	Date	Reason for revision	Revised by
0	28 January 2004	Issued for Permitting Use	T Anderson
1	7 February 2005	Updated and Issue for Permitting Use	R Hanson
2	9 May 2007	Updated section 4.5, 4.6 and Figure 1	R Hanson

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Acronyms and Abbreviations

AEA	*Atomic Energy Act of 1954*
COx	Carbon Dioxide / Carbon Monoxide
DOE	US Department of Energy
HEPA	high-efficiency particulate air
LAW	low-activity waste
NO_x	nitrogen oxides
SBS	submerged bed scrubber
SCR	selective catalytic reduction
VOC	volatile organic compound
WESP	wet electrostatic precipitator

1 Introduction

The two low-activity waste (LAW) melters process mixed waste in a joule-heated ceramic melter to reduce volume and immobilize radionuclides. The resulting offgas is treated in a manner that protects human health and the environment using a variety of unit operations that may, under specified circumstances, be bypassed. A bypass is defined as the intentional omission of one or more offgas treatment steps either as an automated part of system responses or manually. Bypasses are designed into the LAW vitrification offgas system to:

- Allow maintenance of treatment equipment without stopping melter ventilation
- Maintain a ventilation path to the facility stack
- Prevent and/or minimize melter pressurization

This document describes the LAW vitrification offgas system and potential bypass events in accordance with Dangerous Waste Permit Condition III.10.H.5.c.ix (WA7890008967).

2 Applicable Documents

Process flow diagrams associated with the LAW melter offgas system are as follows:

- 24590-LAW-M5-V17T-P0004, *Process Flow Diagram - LAW Vitrification Melter 1 (System LMP & LOP)*
- 24590-LAW-M5-V17T-P0005, *Process Flow Diagram - LAW Vitrification Melter 2 (System LMP and LOP)*
- 24590-LAW-M5-V17T-P0007, *Process Flow Diagram - Melter 1 Primary Offgas Treatment System (System LOP)*
- 24590-LAW-M5-V17T-P0008, *Process Flow Diagram - Melter 2 Primary Offgas Treatment System (System LOP)*
- 24590-LAW-M5-V17T-P0010, *Process Flow Diagram - LAW Vitrification Ammonia & Secondary Offgas (System AMR & LVP)*
- 24590-LAW-M5-V17T-P0011, *Process Flow Diagram - LAW Vit Secondary Offgas Treatment (System LVP)*

Other Documents

- WA7890008967, *Dangerous Waste Portion of the Hanford Facility Resource Conservation and Recovery Act Permit for the Treatment, Storage, and Disposal of Dangerous Waste,* Chapter 10, and Attachment 51, "Waste Treatment and Immobilization Plant."

3 System Summary

The offgas treatment system is designed to accommodate a LAW melter glass production rate of 15 metric tons per day per melter based on the concentrated LAW feed received from the pretreatment facility. Figure 1 schematically depicts the melter offgas system.

The primary offgas treatment system is designed to control the melter pressure, remove heat from the melter offgas, and remove particulates. The system, in conjunction with the exhausters, is designed to accommodate intermittent offgas increases up to seven times the normal steam and three times the normal noncondensable gas generation flow from the melter feed.

The vessel vent header receives offgas from the LAW concentrate receipt vessels (LCP-VSL-00001/2), the melter feed preparation vessels (LFP-VSL-00001/3), the melter feed vessels (LFP-VSL-00002/4), the plant wash vessel (RLD-VSL-00003), the submerged bed scrubber (SBS) condensate collection vessel (RLD-VSL-00005), and the C3/C5 drains/sump collection vessel (RLD-VSL-00004). The offgas received through the vessel vent system consists primarily of air, water vapor, and minor amounts of aerosols generated by the agitation or transfer of vessel contents.

Offgas from the vessel vent header is combined with offgas from the primary systems and routed to the secondary offgas system where the combined offgas is treated to destroy or remove hazardous contaminants. The system also removes potential catalyst poisons that could impair effectiveness of the catalyst treatment unit. After treatment, the offgas is released through a stack.

The primary offgas system consists of the following:

- Primary offgas line with film cooler (LOP-FCLR-00001/3)
- Melter control air
- Submerged bed scrubber (LOP-SCB-00001/2)
- SBS condensate vessel (LOP-VSL-00001/2)
- Offgas piping, valves, pumps, and instrumentation
- Wet electrostatic precipitator (WESP) (LOP-WESP-00001/2)
- Standby line (from the melter to its associated SBS) with
  - Film cooler (LOP-FCLR-00002/4)
  - Butterfly valve
  - Special relief device

This system cools the offgas and removes particulates. A separate primary offgas system is provided for each melter. Changes in gas generation rates affect the melter vacuum, which is controlled by adjusting the flow of control air introduced through the film cooler. The standby line is provided in the event that flow through the primary line is not sufficient to maintain the melter at the desired vacuum. This standby line includes a film cooler and has a butterfly valve as the isolation device. A special relief device between the melter and the butterfly valve in the wet process cell relieves melter pressure at about +10 in. water gauge.

The secondary offgas system consists of the following:

- Melters offgas HEPA preheaters (LVP-HTR-00001A/B)
- Melter offgas HEPA filters (LVP-HEPA-00001A/B, 2A/B and 3A)
- Melter offgas exhausters (LVP-EXHR-00001A/B/C)
- Mercury mitigation equipment skid (LVP-SKID-00001) consisting of the following:
    - Offgas mercury adsorbers (LVP-ADBR-00001A/B)
- LAW catalytic oxidizer/reducer skid (LVP-SKID-00002) consisting of the following:
    - Melters secondary offgas cat. oxidizer heat recovery exchanger (LVP-HX-00001)
    - Melters offgas cat. oxidizer electric heater (LVP-HTR-00002)
    - Melters offgas cat. oxidizer VOC catalyst (LVP-SCO-00001)
    - Melters offgas cat. oxidizer SCR catalyst (LVP-SCR-00001)
- Ammonia/air dilution skid (LVP-SKID-00003)
- Melters offgas caustic scrubber and caustic collection tank (LVP-SCB-00001 and LVP-TK-00001)
- Piping, valves, pumps, and instrumentation

This equipment removes most of the remaining particulates and removes or destroys chemical contaminants.

The vessel vent system consists of a header with lines to process vessels to maintain a slight vacuum that controls emissions both during normal operation and during maintenance.

4 Description of Bypass Events

The following six unit operations perform destruction or removal functions:

1. Submerged bed scrubber
2. Wet electrostatic precipitator
3. HEPA filters
4. Mercury mitigation equipment
5. Catalytic oxidizer/reducer skid
6. Caustic scrubber

With the exception of the HEPA filters, each unit operation can be intentionally bypassed for maintenance. The mercury mitigation equipment, catalytic oxidizer/reducer skid and the caustic scrubber may be bypassed automatically if high differential pressure across the unit is detected. The mercury mitigation equipment may be bypassed automatically if there is an indication of a carbon bed fire. In the event of melter pressurization, the butterfly valve in the line from the standby film cooler is interlocked to open to provide an alternate path.

The melter is enclosed in a shielding box that is separately ventilated via the C5 ventilation system. The C5 system ventilates areas known to be contaminated. If the melter pressurizes with respect to the annulus, offgas leaking from the melter plenum to the annulus bypasses treatment steps except for C5 HEPA filtration. The special relief device in the wet process cell can also act as a bypass since venting to

the wet process cell bypasses treatment steps except for C5 HEPA filtration. There are a total of six bypass events as described below.

All bypass events are preceded by, or followed by, the termination of melter feeds. In the case of a manually initiated bypass, the melter feed is terminated, the cold cap dissipated, and emissions allowed to decline to acceptable levels before the bypass is activated. In the event of melter pressurization, special relief device operation, or interlocked bed bypass, the melter feed would terminate and the cold cap would dissipate as a result of the event.

Each bypass is numbered in Figure 1 to correspond with the sections below.

4.1 Submerged Bed Scrubber/Wet Electrostatic Precipitator Maintenance Bypass

This maintenance bypass connects the standby offgas lines for both melters. It would be used if maintenance needs to be performed on a SBS or a WESP. This is an unlikely event because no routine maintenance is planned, and it is anticipated that the SBS and WESP will be inspected and refurbished, if required, during melter changeout. To use this bypass, both melters are idled, the bypass is opened, the butterfly valve in the offgas train that is not to undergo maintenance is opened, and the isolation valve downstream of the WESP on the system to undergo maintenance is closed. No treatment steps are bypassed for offgas from either melter. This bypass is not expected to result in increases in the environmental discharge of dangerous constituents to the environment.

4.2 Mercury Mitigation Equipment Bypass

This bypass is primarily intended to operate if a fire is detected in the mercury mitigation equipment. Detection of a fire (i.e., increase in COx concentration) or potential fire initiator (i.e., high inlet temperature) would automatically open the bypass to prevent blocking the offgas flow path and close the inlet valves to reduce oxygen to the fire. Feed to the melters would be interlocked to stop at this point. Additionally, if high differential pressure across the unit indicates plugging, this bypass would be activated to avoid melter pressurization and release of offgas into the C5 area of the building. Again, feed to the melters would be interlocked to stop at this point. The bypass could be used when changing out adsorption media, but this would not be necessary because a valving arrangement is provided to allow using just one of the two beds while the other is undergoing maintenance. The melter in normally idled before the unit undergoes maintenance. The automated bypass event would result in slight increases in the discharge of acid gases and mercury until the dissipation of the cold caps is complete.

4.3 Catalytic Oxidizer/Reducer Skid Bypass

This bypass is intended to operate if high differential pressure across the unit indicates plugging. This bypass would be activated to avoid melter pressurization and release of offgas into the C5 area of the building. Again, feed to the melters would be interlocked to stop at this point. This bypass will also be used to change out catalyst. In preparation for this, the melters would be idled and offgas generation allowed to abate. The bypass might also be used for maintenance on the heat recovery exchanger or the electric heater. The automated bypass event would result in slight increases in the discharge of VOCs and NOx until the dissipation of the cold caps is complete.

4.4 Caustic Scrubber Bypass

This bypass is intended to operate if high differential pressure across the unit indicates plugging. This bypass would be activated to avoid melter pressurization and release of offgas into the C5 area of the

building. Again, feed to the melters would be interlocked to stop at this point. Use of this bypass is not expected to be routine because this unit has no routine maintenance associated with it that would require bypassing. In the unlikely event that the packing needs to be cleaned or replaced, the bypass will be used after idling the melters. The automated bypass event would result in slight increases in the discharge of acid gases until the dissipation of the cold caps is complete.

4.5 Melter Pressurization

The standby offgas line supplements control of the melter plenum pressure under high offgas surge situations or if there is a blockage in the main offgas line to the submerged bed scrubber. The melter plenum pressure is controlled at a sufficient vacuum set point relative to the melter cave to avoid contamination release to the melter cave, prevent inadvertent glass pour, and prevent damage from occurring to the primary treatment system. This is accomplished by providing an alternate path by way of the standby offgas line for melter offgas. The standby offgas line is identical in size to the primary offgas line and runs for the same length from the melter to the submerged bed scrubber.

The standby line will normally be isolated from the SBS via a valve. At a low vacuum set point, this valve will automatically open, providing an additional or alternative (if the primary is restricted) path for the melter offgas to flow. The standby offgas pipe extends to the bottom of the submerged bed scrubber packed bed, identical to the primary pipe. Thus, during melter surges the cross-sectional area available for offgas flow effectively doubles, decreasing the pressure drop between the melter and the submerged bed scrubber and helping to reestablish normal melter vacuum. In case of a plug or restriction in the primary offgas pipe between the melter and the submerged bed scrubber, the standby line and valve would activate, allowing melter pressure control to be maintained. Once the cause of the standby valve being activated is rectified, the valve would be closed by operator initiation returning all of the melter offgas to the primary offgas film cooler and offgas pipe. An air purge will be used to keep the standby offgas line clean and prevent blocking.

The standby offgas jumper is automatically activated based on the melter plenum vacuum via a pressure controls interlock. Activation of the standby jumper is most likely to occur under melter feeding conditions and during an upset condition (i.e., melter surge). No loss of offgas abatement occurs upon activation of the standby jumper since the offgas is routed to the same destination (i.e., the SBS) as the primary offgas jumper.

In the unlikely event that an offgas surge exceeds the capacity of the melter offgas pressure control system, and the melter pressurizes with respect to the annulus, outleakage from the melter will bypass treatment steps except for the C5 HEPA filters (4.5a on figure 1). These events / surges are smaller than those that would open the special relief device discussed below. Feed to the melter is interlocked to stop before the melter pressurizes. Air and water to the film coolers are also interlocked to stop and the standby line is interlocked to open before melter pressurization occurs. This bypass event will result in melter offgas being discharged with only HEPA filtration during the period the melter is pressurized. This automated bypass event would result in slight increases in the discharge of acid gases, VOCs, NOx and mercury until the dissipation of the cold caps is complete.

4.6 Special Relief Device Operation

An even more unlikely event is one where an offgas surge exceeds the capacity of the melter offgas pressure control system to a pressure higher than the situation discribed above. In this situation the special relief device would open. If the special relief device on the standby line in the wet process cell opens, vented gas bypasses treatment steps except for C5 HEPA filtration. Note that the special relief

device is intended to limit melter pressurization. Feed to the melter is interlocked to stop before the melter pressurizes. Air and water to the film coolers are also interlocked to stop and the standby line is interlocked to open before melter pressurization occurs. This bypass event will result in melter offgas being discharged with only HEPA filtration during the period the melter is pressurized. The special relief device closes when the line pressure drops below the set point.

4.7 Loss of LAW Facility Power

If power to the LAW facility is lost, the melter could pressurize if the following automatic actions are not completed. Feed to the melter is interlocked to stop on loss of power. Air and water to the film coolers are also interlocked to stop and the standby line is interlocked to open before melter pressurization occurs. This bypass event will result in melter offgas being discharged with only HEPA filtration during the loss of power event until the cold cap is dissipated. Additionally, the mercury mitigation equipment, catalytic oxidizer/reducer skid and caustic scrubber bypasses open to avoid/reduce the release of offgas into the C5 areas of the building. This is a safety requirement to direct NOx gasses out of building to avoid worker exposure. This automated bypass event would result in slight increases in the discharge of acid gases, VOCs, NOx and mercury until the dissipation of the cold caps is complete.

5 Recommendations

Recommendations for preventing the potential for bypass events as well as minimizing their impact and frequency are as follows:

1. Operating procedures: Operating procedures have not been written, but the need to avoid melter pressurization for safety reasons is well documented and there is a large safety focus on the prevention of melter offgas release to occupied areas. The description of procedures will be addressed in accordance with Permit Condition III.10.H.5.c, as appropriate.
2. Maintenance procedures: Maintenance procedures have not been written, but maintenance involving a bypass will not be performed on the offgas system unless the melters are properly idled.
3. Redundant equipment: The HEPA filters have redundant trains. Other treatment systems are not expected to have frequent maintenance and generally have slow and readily detected failure modes. The six pumps in the system each have an installed spare (total of 12 pumps). The exhausters are three 50 % units, two of which are normally in operation and one that is a spare. One exhauster can vent the melters although with a lower capacity to adjust to changes in offgas rates.
4. Redundant instrumentation: Each of the automatic bypasses has redundant instrumentation. Additionally the melter pressurization control has redundant pressure transmitters. The interlock for feed termination is through the safety class Programmable Protection System.
5. Alternate equipment: The offgas system has been extensively analyzed to optimize equipment. Alternatives considered are documented in best available radionuclide control technology, best available control technology, and best available control technology analysis for toxic air pollutants reports. The annulus around the melter provides additional capacity to avoid worker exposure to hot, toxic, corrosive, and radioactive materials.
6. Alternate materials of construction: The materials of construction for offgas equipment were selected based on bounding process conditions. These include exposure to high temperatures, corrosive gases and liquids, and erosion. Materials of construction were selected in a formal process that included

recommendations from material specialists and documentation of the selection of appropriate materials.

6 Conclusion

Bypasses are designed into the offgas system to allow maintenance of equipment without preventing the primary task of venting the melters and controlling melter plenum pressure. The automated bypasses around the mercury mitigation equipment, catalytic oxidizer/reducer skid and caustic scrubber perform an additional safety function of maintaining a flow path to the top of the stack. Three other bypasses can occur as a result of limiting melter pressurization during an upset condition as described in sections 4.5, 4.6 and 4.7.

The primary driver for the offgas system design has been safety, followed by an environmentally compliant discharge. Every effort has been made to avoid bypass events that would challenge either of these goals. All bypass events are either preceded by the termination of melter feed and cold cap dissipation or interlocked to achieve the same result.

Figure 1 Melter Offgas System